The Pando clone in central Utah's Fishlake National Forest is composed almost exclusively of mature stems that are dying off and are not being replaced.

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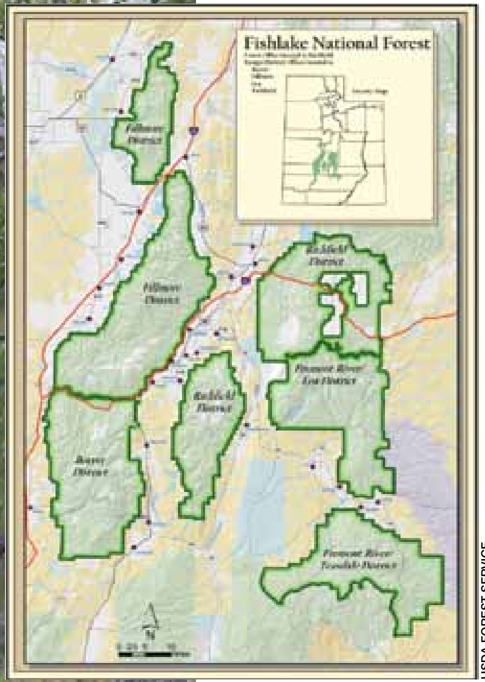
Saving Pando

Humans are taking measured steps to rejuvenate an ailing giant.

BY PAUL C. ROGERS

Last fall, intrepid teenagers in groups of threes and fours fanned out across the Fishlake National Forest in central Utah to put their ideas to the test. The Ogden High School International Baccalaureate class, along with their instructors, came to a place in the forest to see and to learn about what is thought to be the world's largest living organism: a 106-acre clone of quaking aspen (*Populus tremuloides*) stems estimated to weigh thirteen million pounds. Though aspen are the most widespread tree species in North America, the deteriorating state of this clone may bear lessons not only for these students or for the fate of aspen continentally, but for human interactions with nature in general. How this clone came to be and its ultimate arrival in the present predicament is a story of evolving science and shifting stewardship; a partnership born of necessity and urgency.



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In 1968, forest ecologist Burton V. Barnes (1930–2014), professor in what is now the University of Michigan's School of Natural Resources and Environment, identified this huge clone by discerning the difference in annual patterns in leaf color and development from adjacent aspen stands. Twenty-five years passed before evolutionary biologist Michael C. Grant, at the University of Colorado-Boulder, named the clone "Pando" (Latin for "I spread") and dubbed this specimen the World's Largest Organism. In 2008, a team of researchers led by Karen Mock, associate dean of the Quinney College of Natural Resources at Utah State University, confirmed Barnes' original estimate of Pando's size, but also noted a curious ring of much smaller aspen clones surrounding the giant. How these patterns of genetic growth developed over time—perhaps one clone pushing the others aside, or opportunistic seedling establishment near the edges—continues to puzzle modern scientists. Moreover, though we have no dependable method for determining Pando's age, we do know that this huge, genetically identical organism comprised of an estimated 47,000 stems (called ramets) originated from a single seed the size of a pepper grain. The nature of this beast causes us to re-examine what it means to be an individual specimen when what appear to be free-standing trees are actually small elements of a much larger being with a root system that exchanges life-supporting energy among ramets.

Traditional aspen science leans heavily on the fact that the species propagates via root sprouting, also known as suckering. In response to forest disturbance, such as wildfire, logging, or blowdown, aspen sucker profusely to initiate new cohorts. This rapid successional response favors aspen over competing vegetation in the early years, but eventually conifers outmuscle aspen for such resources as sunlight, water, and space. Not all aspen, as in the case of Pando, compete with conifers; some grow

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This six-inch-tall aspen sucker arising from the parent roots of Pando represents future "generations" of the giant clone. Repeated browsing by ungulates results in clipped tops and multiple stems.

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Stems of the same clone may stay connected for decades, although many separate over time.

in nearly pure stands where disturbance does not play a major role. Instead, continuous asexual reproduction from thriving root systems produces patches of aspen stems growing, at any given time, in a variety of sizes and ages.

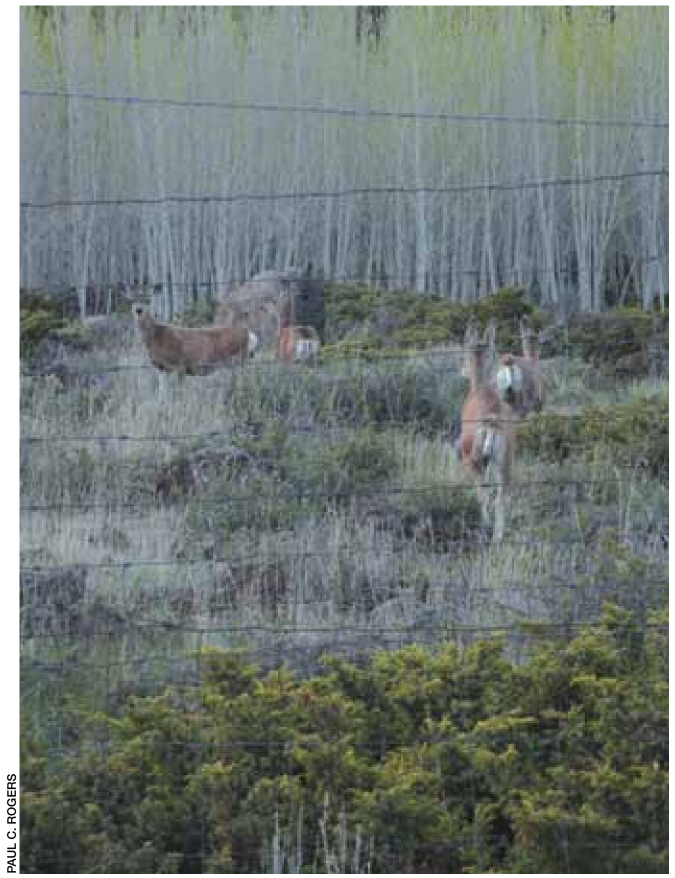
In fact, recent research, such as that coming from Mock and her associates, clearly describes patterns of offspring indicative of regular seedling development—i.e. sexual regeneration. Both root suckers and seedlings have played a role in the life of Pando, though we don't fully understand the relative importance of each.

As the young scientists of Ogden High School quickly discovered, all is not well with Pando. A casual walk through this immense grove soon reveals a decided lack of young ramets, the lifeblood of any healthy aspen forest. The giant that thrives on continuous reproduction appears to have stopped reproducing. If this were a human community, it would be as if there were almost no babies, teenagers, young adults, or even middle-aged people. The Pando clone is made up almost entirely of senior citizens and, as would be the case were this a village, concern for the future of this western icon is well founded.

While we cannot age aspen clones with accuracy, we can determine the ages of stems by taking core samples, just as we do with most tree species. We know that the mature ramets of Pando are predominantly 100-120 years old; elderly specimens for aspen, but not for conifers in this region. The aspen lifestyle, or functional ecology, is to live short lives and reproduce quickly using carbohydrate energy produced in the leaf canopy and stored in the expansive root system. With such aggressive reproductive mechanisms in place, one would guess the clone abounds in young suckers. So, why is Pando missing these age groups?

One likely group of suspects threatening Pando are herbivores. Deer and cattle eat suckers soon after they emerge from the ground. Young aspen stems contain supple twigs loaded with nutrients intended for fast growth. A consistent pattern of herbivorous behavior, lasting over decades, has resulted in a very uneven stem demography. As with all tree species, death of old aspens occurs naturally from a variety of causes, such as internal decay, insect infestation, wind throw, and physical wounds from animals and humans, but mortality without replacement spells potential systemic collapse.

If Pando represents a natural system, possibly thousands of years old, how did it come to this perilous state in so brief a time? There may be several contributing factors, but there's little doubt that people have played a role. Contemporary domestic cattle and wild ungulates are regulated by human agency. Further, over the past century we've been quite successful at reducing or eliminating apex predators that previously swayed herbivore numbers, movement, and habitat. There are economic incentives for keeping both livestock and game animal numbers high. A greater degree of control over livestock allows innovative grazing strategies to keep producers in business while concurrently preserving important resources. With wild game, day-to-day management is more difficult, but long-term populations may be manipulated through regulation and licensing. So, the "naturalness" of this system has been significantly altered over recent decades and the symptoms of decline are now becoming evident within Pando, which is considered a keystone species for numerous plants and animals. Similar aspen stories are playing out across the American West; a combination of drought-plagued forests and overabundant herbivores sets up a slow march toward system failure.



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These mule deer have found ways to crawl under eight-foot-tall fences to access nutrient-rich aspen suckers. The difficulty and expense of maintaining fences present significant challenges to sustaining Pando's future.

Natural resource issues often involve "messy" solutions, in which multiple players represent divergent philosophies, and degrees of intrusion and ecological outcomes are far from certain. An iterative approach for combating complex socio-ecological issues is to develop tentative approaches based on limited information and to monitor progress, making adjustments along the way based on new findings. So-called "adaptive management" prevents the employment of policies assumed, without supporting data, to have positive outcomes, and their pursuit to potentially deleterious ends. When managers implement actions without ongoing monitoring, they miss opportunities to learn from either successes *or* mistakes.

In 2013, a plan was developed by Utah State University, USDA Forest Service, Utah Department of Wildlife Resources, and Grand Canyon Trust to enclose about fifteen acres (fourteen percent) of Pando with eight-foot fencing and to conduct experimental treatments within that area. It was hoped that outcomes of this experiment would provide a course of action for sustaining Pando's future. The goal was to allow new aspen stems to grow beyond the height of ungulate reach, as well as to determine which treatment method resulted in the best growth response for money spent. Monitoring began just after the fence was erected and an annual re-measurement is ongoing. Thirty-five sample plots, each containing two 100- by 6-foot transects, were located inside and outside the fenced area and various combinations of treatments—burning, juniper removal, and partial cutting—were applied on both sides. Inside the fenced area, control plots also tested the effect of only fencing without any other treatments. In addition to tallying different aspen stem sizes and status (alive or dead), field personnel noted browsing level on small aspen and counted both deer and cattle scat to gain measures of animal use and presence. It was important for researchers to clearly understand what actions were effective and which animals, if any, were causing recruitment loss.

Preliminary test results are beginning to shed light on Pando's situation. Since the 2013 fence was erected, browsing inside the fence has essentially stopped—although not as completely as expected—and aspen suckers are growing between two and three feet annually in both treated and untreated areas within the fence. One hundred percent browsing and almost no surviving regeneration is taking place outside the fence. Initial data indicate a slightly higher rate of aspen regeneration where sites were purposely disturbed versus those that were only protected. There was no significant difference among manipulations (burning, juniper removal, and partial cutting) in terms of their regeneration response. Overall, it is clear that the temporary fence is having a

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Experimental burning within an ungulate exclosure was conducted in 2014 to clear undergrowth and stimulate aspen suckering.

positive effect on recruitment success, even in control plots where no active manipulation, other than fencing, was undertaken.

Apparent success after the first year of monitoring prompted USDA Forest Service officials to greatly expand in 2014 an older fenced area. This original fence was constructed in 1992 after earlier trials of clear-cutting aspen within a section of Pando resulted in a complete loss of forest cover and regeneration due to browsing animals. After one year, the expanded fenced area showed little positive response, though there is evidence that mule deer have found ways to crawl under older, deteriorating portions of this fence. In fact, monitoring conducted by the visiting high school students over a twelve-acre portion of this larger exclosure revealed only one young aspen stem. Students also spotted deer within this protected area. Given current numbers of live mature trees, this plot would need at least twenty-two young stems to replace the current overstory, or canopy, of Pando. This number assumes, however, that none of the new recruits die before maturity; in reality, there is great attrition over the lifespan of aspen. Thus, the number of recruits should be double or triple the number of mature trees they replace in order to maintain the overstory. As the mortality of larger aspen trees continues, it further reduces total clone leaf area. Fewer leaves means reduced photosynthesis, which produces carbohydrates banked in the roots—the "fuel in the engine" for future sucker production. The stop-gap fencing is intended to promote juvenile stem survival in order to stymie this negative feedback loop by replacing decaying portions of this immense organism. By continually taking the pulse of Pando's regenerative capacity, and remaining open to course corrections where the data warrant change, a sober strategy for saving Pando seems to be in place.

The Ogden High School students who prowled the forest floor last fall were probing basic research questions. How is plant diversity related to aspen cover? Do soil properties affect ramet health? What is the relationship between tree age and size; can one predict the other? Lessons learned at Pando not only add to their intellectual growth, but have the potential to inform future aspen stewards. Conservationist Aldo Leopold advised, "To keep every cog and wheel is the first precaution of intelligent tinkering." If a single plant of such size and putative age were to collapse now, we should regard this as a faltering of our society to preserve that which has survived the ages.

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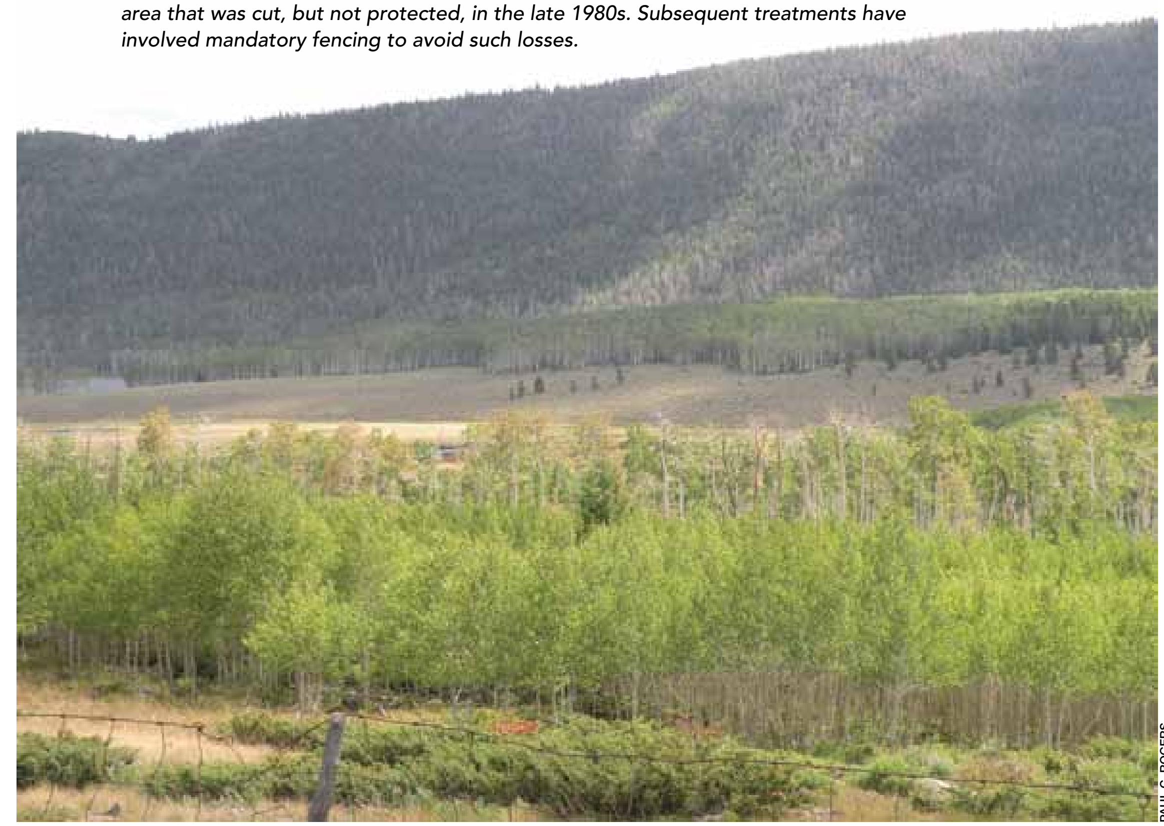
Though cattle are excluded from portions of Pando, short-term access in early summer and autumn, alongside continuous deer browsing, appears to be keeping all young aspen growth in check. The US Forest Service and partners are collaborating to reduce animal grazing and allow successful aspen recruitment before aging canopy stems die off.

Pando probably arrived at its current state due to negligence in human decisions regarding livestock, wildlife, or both. Prior to fencing, based on circumstantial evidence of browse levels and scat deposits, cattle, deer, and possibly elk reduced the ability of the clone to survive without intervention. Presumably, there is a threshold beyond which further death of overstory trees decreases the ability of root systems to produce enough offspring to survive even with low levels of ungulate herbivory. It appears we are at that point. Current efforts to fence Pando piecemeal are showing positive results, although continual browsing in unprotected areas leaves little hope that peripheral portions of the clone will sustain themselves.

Pando is visible in the middle ground, while the non-forested foreground depicts an area that was cut, but not protected, in the late 1980s. Subsequent treatments have involved mandatory fencing to avoid such losses.



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Across the West, quaking aspen face myriad challenges, such as fire suppression, drought, warming temperatures, development, and hydrologic re-engineering. Where herbivory is problematic, it exacerbates these problems. For example, drought-induced instances of mature aspen die-off increases the pace of clonal collapse where few young trees survive browsing. Still, there are many places where healthy communities persist, so we should use caution in projecting the ills of a single locale across the entire region. Moreover, solutions found at this scale, such as fencing out large herbivores, are not feasible on much larger landscapes due to cost, public outcry, or policy restrictions.

The value of aspen ecosystems reaches far beyond the beauty and elegance of a single clone or even the entire species. Quaking aspen, as the most dominant broadleaf in a region of conifers, is widely recognized as a foundational element with numerous obligate plants and animals. Therefore, thriving or failing aspen clones engender cascading effects on biodiversity at large. This exceptional being called Pando represents not only a milestone of single organism size, but a potential laboratory for broader aspen stewardship, as well as an essential forest component for creatures that reside in its shade.

Diverse organizations are coming together to save Pando. We will surely learn as we go and, hopefully, remain vigilant as we make inevitable adjustments along the way. The greatest optimism is lodged in the simple acts of curiosity and discovery found in the minds of budding scientists. To wander the woods, to daydream, to form hypotheses, and to test them—sometimes succeeding, sometimes failing—presents a model for our society to embrace. Pando represents vital links: plant to animal, soil to tree, water to roots, humans to environment. Pando's peril points to broader disconnections, while its perseverance spells hope.

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